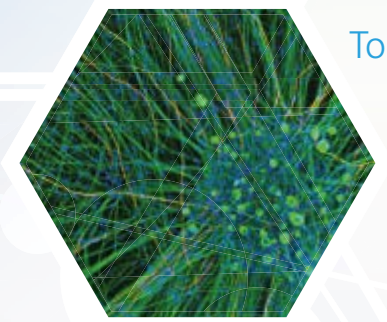
Developing University–Industry Partnerships Fit for the Future

Key Insights and Issues Emerging from the Oxford UIDP Summit 2019



Tomas Coates Ulrichsen

Foreword from the Keynote Speakers

As the Oxford UIDP Summit in 2019 aptly showed, the interface of universities and industry has never been more important.

We are living in extraordinary times: our global population of 7.5 billion people and rising, with all the demands we make on natural resources and the waste that we produce, is experiencing an unprecedented set of global and societal challenges.

At the same time, we have witnessed major technological changes in the form of extraordinary feats of engineering and innovation, some of which have the potential to help us navigate these challenges. As I said in my Summit speech, the gap between the digital, physical and biological worlds continues to narrow and it is in this space that some of the most exciting opportunities for collaboration between academia and industry, as exemplified by the Oxford-UIDP partnership, can be found.

The report that follows explores emerging themes from the Summit in 2019, taking a broad and critical approach to important issues such as making data-informed decisions for partnering, creating a talent pipeline, public engagement and diversity, which are key drivers in academia-industry partnerships on both sides of the Atlantic.

It is a solid starting point for a considered exploration of how universities and funding organisations can best support the researchers who generate the knowledge that societies need, and connect them to the innovators that can turn this knowledge into public benefit.

Sir Mark Walport, Chief Executive, UKRI

The 2019 Oxford UIDP summit uniquely highlighted the importance of public and private sector engagement for impactful science and translational research.

The rapidly changing landscape of research and development is addressing emerging markets, convergent technologies and societal needs – both on this planet and at the frontiers of space. This dynamic environment provides new challenges and risks, as well as opportunities for innovation and entrepreneurship to create value and positive impacts. Companies, universities and public sector institutions increasingly see the need to reinvent themselves for sustainability and relevance, and also to effectively address a hypercompetitive global scene.

New models of public-private partnerships and the flexibilities to enable them will be critical elements in bringing the contributions of research advancement to entrepreneurial startups and to enable transformation of existing businesses. New tools for productivity through artificial intelligence, advanced manufacturing, ubiquitous connectivity, structural biology, and quantum systems demand a new future workforce. Emerging business models further demand establishing a foundation of trust through understandable, meaningful technical standards underpinned by sound, ethical decision-making.

As shared at the UIDP Oxford Summit, the U.S. Return on Investment Initiative has been examining these issues of innovation and public-private partnerships across our stakeholder communities for the past several years. I anticipate that this work, outlined in the report that follows, will contribute further to trans-Atlantic collaborations, innovation outcomes and societal benefits.

Walter G Copan, Under Secretary of Commerce for Standards and Technology and Director, National Institute of Standards and Technology

Foreword from the Summit Hosts

The Oxford UIDP Summit brought together universities, industry and government – the so called triple helix – from across the globe to discuss and identify those pressing challenges and exciting opportunities where we can work together more effectively for our mutual benefit, but also for the benefit of commerce and society. We are grateful to the UIDP organisation and community for offering their expertise and mobilising their members to contribute to the success of the Summit.

As the interactions during the Summit showed, we are keen to do this better, to learn from colleagues, and happy to share what we think we do well. Together, we can best understand the challenges of the future and be positioned to respond. The Summit report captures the fantastic discussions that occurred during the sessions, and the three projects/thematic areas that UIDP can take forward as firm outcomes of the meeting.

Effectively addressing the major issues facing our society and responsibly seizing the opportunities presented by technological developments will rely on great communication between the strands of the triple helix. I look forward to continuing the conversations started and building on the ideas generated in Oxford.

Patrick Grant, Pro-Vice-Chancellor (Research), University of Oxford

The distinctive Butterfield-designed architecture of Keble College set on magnificent quadrangles, with dining in awe-inspiring Keble Hall, was the University of Oxford venue for that rarest, but absolutely vital, opportunity for a robust exchange of ideas among an international set of academic, industry, and government research leadership. The range and diversity of the discussions represented the great scope of issues and challenges we face. Yet it also provided new openings to conceive solutions. In this intimate, inspiring setting, it became clear that professionals from across the globe find common ground on the need for greater engagement—to increase diversity in research settings; to balance ethical responsibility with the promise of new technology and big data; and to find new ways to partner across sectors and disciplines—all for the greater benefit of humanity. It is this forthright discussion that forms the basis of this report, and the foundation for us to continue the collegial discussion and deepen our understanding. The University of Oxford was the first English-speaking university in the world; it was also UIDP's first international university member. And when the time came for our organization to extend our unique convening capabilities to an international forum, Oxford was our first choice. In what better setting could we convene 150 thought leaders from throughout the world to talk about improving the way universities, industry, and government entities work together to advance innovation and improve the products and services that serve people across the globe?

Jay Walsh, Chair, UIDP Board

Foreword from the Report Sponsor

The ways in which the research base and business connect are increasingly diverse and increasingly important. The Oxford UIDP Summit 2019 provided the environment to bring together a group of key opinion leaders to explore how these interactions are evolving and to share best and emerging practice. Through a combination of plenary talks and workshops the programme provided opportunity both to think big and to have more detailed discussions, challenging us as policy-makers, companies, universities and funders to reflect on ambition and practice. The mixture of delegates and speakers from the USA, UK and Europe and from all parts of the triple helix ensured a diverse and insightful event. Whilst many policy initiatives and partnership programmes presented/discussed had their own national or regional flavour, there were some very clear commonalities in purpose: stimulating R&D to drive innovation; enriching the talent pool and responding to new technologies and emerging opportunities. In this vein, topics such as the relevance of non-STEM disciplines and researcher porosity between business and universities were particularly current.

The Summit proved the breadth of knowledge transfer and its relevance to the economy. But there is no room for complacency. Coherent policy, practice and resourcing that is current and agile are vital to success. This report details the richness of the discussions that took place during the Summit and distils the emerging calls to action. It offers an important waypoint as we drive for excellence in innovation through partnership.

Alison Campbell OBE, Director, Knowledge Transfer Ireland

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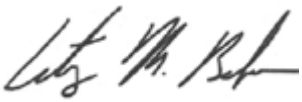
Acknowledgements

The evidence and insights that form the basis of this report were drawn from the many interesting and lively presentations, discussions and debates at the University of Oxford UIDP Summit 2019. We are indebted to the many speakers and delegates who attended and contributed actively and forthrightly to these discussions. We would also like to thank the Programme Committee for providing the strategic direction and working tirelessly to secure speakers and attract delegates. The committee, drawn from universities and businesses on both sides of the Atlantic, brought their considerable knowledge and networks to bear, designing a thoughtful and topical agenda with many insightful speakers. We are grateful to the University of Oxford and the UIDP team and many unsung heroes who made it work. Together, we're bringing forward many of the lessons learned—as well as new questions raised—in our ongoing work to support strong, collaborative, cross-sector partnerships. Ultimately it was the combined efforts of the university-industry partnering community that made the event a success.

Phil Clare, Deputy Director, Research Services (Knowledge Exchange and Engagement), University of Oxford



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Joe Marshall, Chief Executive, National Centre for Universities and Business

Patrick Grant, Pro-Vice-Chancellor Research, University of Oxford

Grace Wang, Senior Vice Chancellor for Research and Economic Development, The State University of New York

Acknowledgements

SPEAKERS

Simon Andrews, Fraunhofer UK Research

Greg Autry, University of Southern California

Nicky Athanassopoulou, IfM Education and Consultancy Services

Ramtin Attar, Autodesk

Paul Beasley, Siemens

Dave Bembo, Cardiff University

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Angel Hedberg, RTI International

Meghan Houghton, National Science Foundation

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Karl Koster, Massachusetts Institute of Technology

Angela Kukula, The Institute of Cancer Research

Joe Marshall, National Centre for Universities and Business

Stuart Martin, Satellite Applications Catapult

Angela McKane, BP

Emmo Meijer, Topsector Chemistry

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1

Introduction

The relationship between government, universities, and industry has never received such urgent attention as it does now. Countries around the world, not least in the United Kingdom, United States and Europe, wrestle with the question of how to take knowledge generated and developed in their universities and harness it for the good of the economy and humankind through technology transfer and collaboration with global businesses. Many large companies and universities are also striving to find more effective and productive ways of engaging, reflecting the many challenges that have to be overcome to manage partnerships to create and capture value, and the changing global and competitive landscape within which they operate.

While much progress has been made to-date, the constantly shifting national, industrial, technology, socio-economic landscapes mean that governments, universities, companies and other organisations must continuously invest time and effort in understanding the latest trends, emerging issues, and what works and does not for building effective and valuable partnerships.

Against this backdrop, the University of Oxford in the UK, and the University-Industry Demonstration Partnership (UIDP) in the US, joined forces in 2019 to develop and host the inaugural Oxford UIDP Summit. This brought together 149 senior leaders and managers from leading universities, companies and governments from the UK, US, Europe and further afield, to identify new and better ways to partner to advance the human condition and key issues that need to be addressed.

Types of delegates attending the Oxford UIDP Summit 2019

Geographical Split		Organisational Split	
UK	74	University	76
Rest of Europe	24	Industry	41
US	45	Government	16
Rest of the World	6	Interface Organisations	16

Going into the Summit, the Programme Committee – comprised of thought leaders on university-industry partnerships from university and industry partnering community, academia, and government agencies – identified the following key issues for exploration:

- The need for better approaches for finding collectible, telling metrics to inform university-industry partnership development
- Understand the opportunities for developing artificial intelligence and machine learning solutions to inform university-industry partnering decisions and contribute to partnering activities, and explore the issues involved in exploiting big data in this way
- Examine new models for developing partnerships and engagements with research institutions as shifting global structures prompt them to consider how to intelligently prepare for the future

Following three intense days of discussion and debate by the Summit delegates in a mix of expert panel sessions and facilitated breakouts, the following areas emerged that were seen as key for the future development of effective and productive university-industry partnerships:

i. The changing landscape for university-industry partnering
ii. Strengthening partnership models and key trends at the university-industry interface
iii. Moving beyond traditional university-industry partners to capture new opportunities
iv. Developing metrics for university-industry partnering
v. Data-informed decisions for partnering and issues of artificial intelligence
vi. National R&D targets: helpful or misguided?
vii. University-industry partnering and the emerging roles of intermediaries
viii. Diversity in university-industry partnering: difference is beautiful
ix. Delivering a pipeline of talent and increased people mobility
x. Reconnecting with the public on the value of research

Throughout the many sessions, delegates emphasised the benefits of encouraging diversity – in all its many forms, gender and sexuality, ethnicity and disability – in university-industry partnering activities. The discussions reinforced the growing body of evidence that shows that more diverse teams lead to more creativity, bringing broader views, experiences and perspectives to talking problems, and ultimately leads to improved outcomes. Furthermore, diversity was encouraged in terms of reaching out more proactively to those parts of universities that have historically been less involved in partnering in the social sciences and humanities. There is growing recognition of the significant value teams with a diverse range of people involved can add to many university-industry partnerships.

The remainder of this report presents the key insights and issues emerging from the Summit in each of these areas.

2

The changing landscape for university-industry partnering

The first key issue that emerged at the Summit was the significant shifts in the underlying landscape facing universities and companies as they develop and nurture partnerships and translate research into valuable applications with socio-economic impacts. These shifts are occurring in many areas and at many different levels. At the global level, major societal challenges have resulted from ageing populations and intensifying climate change. Furthermore, with the rise of populism societies have become more unpredictable and increasingly question the status quo, not least in terms of the functions and validity of established socio-economic and political institutions and the conduct and societal responsibilities of large corporations.

Universities and companies are also operating in period of significant and rapid technological change, with the gap between the digital, physical and biological worlds narrowing considerably. We are observing the growing fusion of technologies across sectors, increasingly being powered by the convergence and integration of science, technology, engineering and mathematics (STEM) and the social sciences, arts and humanities. Furthermore, the rise of big data, artificial intelligence (AI) and machine learning (ML) is transforming what is possible in many industries. All of these changes are creating large opportunities for innovation. At the same time they are causing significant challenges particularly for large incumbent organisations in established industries who need to be able to adapt and reorient themselves to maintain their competitive positions.

Coupled with these changes are significant disruptions to the business models in many industries, which are fundamentally changing how value is created and captured. For example, the rise of technology 'platform' companies, such as Uber and Airbnb have been able to establish effective interfaces between the producers of goods and services and consumers. By controlling these interfaces, these companies have disrupted how value is captured in these industries and have left many traditional providers struggling to compete. Another significant change is the blurring of the boundary between manufacturing and services, for example with many manufacturing companies developing key service offerings related to the sale, use and maintenance of their core products. A classic example of this is the shift made by Rolls-Royce from selling aircraft engines to contracting with customers for 'power-by-the-hour', with all the support (including maintenance) included in the contract[1]. This 'servitisation' of manufacturing is changing how value is distributed along the value chain and is creating new opportunities for companies to capture additional value.

The ways in which companies organise their innovation efforts is also changing, from the individual-inventor approaches of the 19th Century to the rise of the large corporate R&D labs in the mid-20th Century to the more open and distributed innovation models of the early 21st Century enabled not least by the advances in information and communications technologies, the World Wide Web and the Internet. This has raised key questions for companies:

- How are they going to identify new innovations (which may well be being developed externally)?
- How are they going to access and exploit innovations developed externally?
- How are they going to filter the different technological options available to make effective choices about the way forward?
- How are they going to capture value from innovation in an increasingly distributed and networked world?

1 *Neely, A., 2007. The Servitization of Manufacturing: An Analysis of Global Trends*

Major changes are also happening at the research level. There is a growing importance of interdisciplinary research that reaches not only across different STEM disciplines, but that also effectively integrates the social sciences, arts and humanities. This recognises the critical importance of the latter, for example in helping to understand the potential societal implications of particular paths of technology development, ethical and regulatory issues, and whether and how users will be willing to accept emerging technological solutions to key challenges. As with industrial innovation, the developments in digital technologies are having significant effects in how research is conducted. Digital tools – such as AI/ML, data and visual analytics, robotics, and blockchain, are intensifying science and innovation making it easier to 'fail' and faster to learn (e.g. through the ability to perform millions of iterations very quickly).

All of these changes create challenges for universities and companies, requiring them to adapt to new contexts. For those that do, they are able to unlock new, high value opportunities, often driven by effective university-industry partnerships at their core.

2.1 The changing policy environment for research and innovation

Coupled with these changes to societies, technologies, business models and the world of research are evolutions to the nature of science and innovation policies in the US, UK and Europe Union. Far from the core focus in the mid-20th Century on the funding of basic science, today's policies have shifted to emphasize portfolios of investments that cover not just fundamental research but also applied and translational research, and mission and challenge-driven research. Furthermore science and innovation policies in these areas are increasingly emphasizing 'knowledge with impact' and how they can nurture the pathways from knowledge to socio-economic impact. A wide range of funding programmes and incentives have been established to support not just the production of knowledge but also its translation into applications[2].

In the UK, the past decade has seen an increasing emphasis on considerations of impact in research funding allocations. For example the Research Excellence Framework, which guides the allocation of the block (formula-driven) grants for research, now includes assessments of both the academic standard of scholarly outputs as well as the impact of the research portfolios of university departments. Academics are also now routinely asked to articulate pathways to impact in their grant funding proposals.

The UK has, in recent years, also seen significant increases in the science budget, with an additional £4.7 billion being committed over the 4 year period to 2021/22. A sizeable amount of this is being allocated to address challenge driven and strategic national research and innovation priorities through the Industrial Strategy Challenge Fund (ISCF), investing in areas such as quantum technologies, compound semiconductors, healthcare, agritech, energy and clean growth, and the creative industries. These challenges are typically industry-led, industry-engaged and place a strong emphasis on strengthening the partnerships between academia and industry. Alongside this have been increases in the amount of funding targeted at the strengthening of the exchange, translation and diffusion of new knowledge into socio-economic applications.

Another recent development in the UK is the rise of place-based funding for research and innovation as part of the industrial strategy. For example the £235 million Strength in Places Fund seeks to address the significant regional disparities in economic performance across the UK. The fund encourages regional consortia of universities, companies, local government actors and others to assemble and bid for resources to invest in research and innovation activity locally that will deliver significant local economic outcomes. This recognises the

2 See for example Chapter 4 (Policy instruments and policy mixes for knowledge transfer) of OECD, 2019. University-industry collaboration: new evidence and policy options. OECD, Paris.

"The quality of the discussion, the quality of the participants, the range and the diversity of the discussions is absolutely right on the nail for the issues and challenges we are facing today in this sphere of industry partnerships with universities."

Anna-Marie Greenaway, BP

importance of geographically targeted research and innovation investment in the seeding and emergence of clusters with universities as core anchor institutions. It represents a significant departure from the status quo which has traditionally invested in research and innovation based on national 'excellence' criteria, without considerations of place.

In the US, there is a recognition that in order for the $150 billion of federal investments in R&D per year to contribute to the economic vitality, competitiveness and national security of the US more has to be done to translate and diffuse the results of these investments. Not least through applied research and services to the public, and the maturation and transfer of knowledge to companies to create new products and services. Public-private-partnerships in R&D and its diffusion – such as the Manufacturing USA initiative and the Hollings Manufacturing Extension Partnerships – are a key mechanism for achieving this.

Supporting this is an effort by the US Federal Government to identify and address key obstacles to effective technology transfer in the US through the Return on Investment (ROI) Initiative for Unleashing American Innovation. Led by the National Institute of Standards and Technology on behalf of the Department of Commerce as part of the Lab-to-Market Cross Agency Priority (CAP) Goal, the ROI Initiative seeks to "*maximize the transfer of Federal investments in science and technology into value for America in ways that will (a) meet current and future economic and national security needs in a rapidly shifting technology marketplace and enhance U.S. competitiveness globally, and (b) attract greater private sector investment to create innovative products, processes, and services, as well as new businesses and industries*". Its efforts are organised around the following core areas for improvement:

- Identify regulatory impediments and administrative improvements in Federal technology transfer policies and practices;
- Increase engagement with private sector technology development experts and investors
- Build a more entrepreneurial R&D workforce

- Support innovative tools and services for technology transfer
- Improve understanding of global science and technology trends and benchmarks.

Discussions at the Summit emphasised the importance of long-term strategic plans for R&D and knowledge exchange/technology transfer. These crucially provide a framework for identifying the variety of complementary activities and investments in all necessary areas required to achieve specific and targeted goals in the long-term, for example integrating areas such as technology development, workforce development, and supply chain development. Given the breadth of activities required it is inevitable that multiple government departments and funding agencies will need to be involved. Effectively developed, a long-term, outcome-driven strategy can help to convene and coordinate the necessary stakeholders and secure their buy-in to deliver a set of common goals. One example here is the request by the US Congress for a clear and comprehensive strategic plan to be developed to sustain American leadership in advanced manufacturing. This identified three core goals: to develop and transition new manufacturing technologies; to educate, train and connect the manufacturing workforce; and to expand the capabilities of the domestic manufacturing supply chain.

All of these various policy-level developments reflect a growing recognition by funders of a need to demonstrate to taxpayers that their investments are not just generating discoveries but that these are being translated into positive outcomes for society. It also reflects shifts in the role for government in science and innovation policy, and the way they are willing to support this knowledge and technology translation process. This includes investing not just in the production of new knowledge but also playing a more active role in facilitating its translation into applications both through additional targeted investments in the commercialisation of technologies, and in helping to reduce the obstacles in the national innovation system hampering this journey.

These global shifts are placing evermore pressures on universities, companies and governments to work more closely and strategically to deliver solutions to the many and varied pressing socio-economic, technical and industrial innovation challenges facing society.

3

Strengthening partnership models and key trends at the university-industry interface

Strengthening the effectiveness and value of university-industry partnerships requires universities and companies to continually learn from their experiences to improve existing models and experiment with new models. The impetus for developing new approaches can come from many places, for example:

- Internal and external pressures (e.g. from within universities or companies, local ecosystems, or national governments) to deliver step changes in the scale and depth of engagement between universities and companies
- Funding pressures requiring universities and companies to find new ways of working
- Shifting industrial, socio-economic and political landscapes requiring new types of partnerships, infrastructure and institutions to be created to pursue opportunities
- Greater understanding of the pathways from research to socio-economic impact and the necessary resources, infrastructure and support required to translate emerging technologies through the so-called 'valley-of-death' into industrial application
- Companies needing to work harder to attract the best researchers and universities to work with them as the landscape for partnerships becomes more crowded

This Summit highlighted a number of key trends at the partnering interface in how universities and companies were seeking to build more effective partnerships. These included:

- Strategically developing local innovation ecosystems to underpin more effective university-industry partnerships
- Developing new organisational vehicles for university-industry partnerships
- Connecting innovation partners through universities
- Building more effective university-industry consortia
- Opening up of company resources to facilitate more productive research engagements
- Integrating social sciences and humanities into university-industry partnerships

Strategic partnerships formed for the longer term between universities and companies as a means of growing high value interactions between the partners continue to be an important part of the partnering landscape. Effective practices for developing these partnerships were explored in depth in a 2014 workshop convened by the Centre for Science, Technology and Innovation Policy at the University of Cambridge in partnership with the UIDP and PraxisAuril with lessons and insights continuing to resonate within the partnering community[3].

3.1 Strategically developing local innovation ecosystems

There was a growing recognition at the Summit that strengthening and enhancing the local innovation ecosystem around the university in a strategic and targeted way can strengthen the value proposition for attracting industrial partners. Innovation ecosystems can be thought of as the sets interdependent players and processes who together, through their interactions, make innovation happen. Players include both companies and other organisations including providers of knowledge (universities, research institutes), finance (e.g. banks, private equity, venture capital, business angels), and those setting the institutional 'rules of the game' that influence and constrain the behaviours of the players and how they interact[4].

3 Ulrichsen, T.C., O'Sullivan, E., 2015. Building Long Term Strategic University-Industry Partnerships: Lessons and effective practices from UK and US experiences. Centre for Science, Technology and Innovation Policy, University of Cambridge

4 For a detailed discussion of innovation ecosystems see e.g. Fransman, M. (2018) Innovation Ecosystems: Increasing Competitiveness, 1st ed. Cambridge University Press.

Speakers at the Summit highlighted the following advantages of working more strategically to build their local innovation systems:

- Strengthening innovative capabilities of local companies to enable them to absorb more of the new knowledge and technologies emerging from local universities, and retain more of the impacts locally
- Accelerating the translation of science into application by providing more targeted and coordinated support through the technology development journey
- Developing specialist facilities to facilitate the research and translation process
- Raising the profile of the region
- Improving the culture for innovation in the region
- Developing and aligning a vision for innovation amongst key players in the local ecosystem
- Improving the ability to attract talent to region

Furthermore, developing critical mass and increasing the density of knowledge generating and innovating organisations in the ecosystem was believed to help:

- Increase interactions between local players (companies and other organisations) who are key to making innovation happen locally
- Reduce the search costs for knowledge and talent
- Increase the chances of serendipitous discoveries and linkages forming, and make it easier for knowledge to flow through the system
- Increase the mobility of people within the system, further strengthening the flow of knowledge through the innovation system to productive uses

Speakers also noted that building more effective local innovation ecosystems for university-industry partnering required thinking about the types of sectors operating locally and their specific technical and broader innovation needs, and how universities can contribute. This resonated with the work of MIT's Richard Lester[5] who found that how universities contribute to their local innovation systems depends critically on the types of sectors present and where these are at in their industrial lifecycle. Figure 1 captures the different types of contributions.

Figure 1 Contributions by universities to local industry

Type 1: Emerging industries

- **Forefront science and engineering research**
- **Technology licensing policies**
- **Promote/assist entrepreneurial businesses (incubation services, etc.)**
- **Cultivate ties between academic researchers and local entrepreneurs**
- **Creating an industry identity**
  - **Participate in standard-setting**
  - **Evangelists**
  - **Convene conferences, workshops, entrepreneurs' forums...**

Type 2: Importation/transplantation of industries

- **Education/manpower development**
- **Responsive curricula**
- **Technical assistance for sub-contractors, suppliers**

Type 3: Diversification of existing industries into technologically related new ones

- **Bridging between disconnected actors**
- **Filling 'structural holes'**
- **Creating an industry identity**

Type 4: upgrading of existing industries

- **Problem-solving for industry through contract research, faculty consulting, etc.**
- **Education/manpower development**
- **Global best practice scanning**
- **Convening foresight exercises**
- **Convening user-supplier forums**

Figure 1:Lester, R. (2005) Universities, Innovation, and the Competitiveness of Local Economies: summary report from the local innovation project — phase I, Cambridge, MA: Industrial Performance Center, MIT.

5 *Lester, R. (2005) Universities, Innovation, and the Competitiveness of Local Economies: summary report from the local innovation project — phase I, Cambridge, MA: Industrial Performance Center, MIT.*

Many universities are experimenting with different types of support for innovation in their local ecosystems. Examples discussed at the Summit included among others:

- Efforts to connect a university's startups to their network of industrial partners
- Developing targeted innovation support services and infrastructure (e.g. innovation centres) for local innovative SMEs
- Convening new sources of finance to support the commercialisation of technologies locally

However, speakers at the Summit argued that careful thought needed to be given to the stages of the commercialisation journey of new knowledge from prototype development through to full scale deployment of the product or service in the economy. Different types of support and resources will likely be required at different stages of this process. It is thus helpful for universities to understand the specific technology development processes that are relevant to the local innovation ecosystem and map the support that is available, either through the university or other local organisations. Where gaps exist, thought then needs to be given to what could be done to close them.

Part of the development of the local innovation ecosystem also required thought being given to how to make it more conducive for innovation. For example: increasing the density of different types of players; alleviating key infrastructural issues hampering innovative activities and enterprises such as planning, transport, communications, healthcare and education etc.; and improving quality of life. As some of the largest employers and land owners in their local economies, universities can play a significant role in partnership with local governments to influence these types of local economic development issues for example through:

- Targeted developments to create new innovation 'districts' and increase the density of innovative organisations in proximity with the university
- Proactively attracting certain types of companies and workers
- Facilitating linkages between companies and the university in support of innovation
- Developing green spaces and the cultural attractiveness of the area to increase quality of life
- Informing local governments of key infrastructural constraints and working together to find solutions

Lastly, developing an effective local innovation ecosystem requires strong leadership, and the building of local coalitions involving key local stakeholders from universities, industry and government, not least to develop a common local vision for innovation and a strategy for realising it. Trust between the key players and buy-in are critical.

3.2 Developing new organisational vehicles for university-industry partnerships

Universities, companies and government agencies are experimenting with new and innovative organisational 'vehicles' to facilitate different types of collaborations to enable greater benefits to be realised from these partnerships. These can facilitate activities which may otherwise be difficult to carry out within traditional university structures, for example:

- translational R&D activities necessary to advance technologies and knowledge towards application
- flexibility to hire different types of scientists, engineers and technicians with a variety of employment contracts and incentives
- ability to put in place different types of facilities, equipment and data security
- capability to manage different types of intellectual property

These types of structures can help the university-industry partnerships bridge the 'valley of death' in technology development and accelerate research laboratory outcomes into deployment. Examples were given at the Summit where such structures focused on targeting not just the large company at the head of the supply chain, but also the technology needs of companies within it.

3.3 Connecting innovation partners through universities

It has long been recognised that universities play an important 'public space' role in innovation systems. As typically stable organisations that are largely devoid of political and industrial agendas, they can act as neutral spaces conducive to *catalysing interactions* within the innovation system. This may be between academics and innovating organisations or between innovators operating in different parts of the system and sectoral value chains and can provide a critical function in helping to strengthen the innovation system by bridging disconnected or weakly connected players[6]. A practical example of how this can be done was provided by a university at the Summit. They have created a new programme to link their start-ups to their many industrial partners. This recognises an important issue of 'asymmetric information' that plagues the commercialisation of novel technologies emerging from the research base; that the inventor of the technology has much more information about its capabilities and potential than do potential partners than can supports its journey to market. The university, with knowledge of both the start-up's capabilities and of the interests of their industrial partners, can act as a broker and facilitate connections between them.

3.4 Building more effective university-industry consortia

A key topic of discussion and debate at the Summit was how to build university-industry consortia fit for the 2020s and beyond; consortia that can more effectively tackle the significant technical and socio-economic challenges facing our societies and industries and create new opportunities for value creation and capture. The importance of this topic reflected the significant potential for consortia to leverage the joint capabilities and resources of different types of partners in academia, industry and government to address these challenges in collaboration. However, there are concerns that existing models are no longer fit-for-purpose and that more has to be done to remove barriers to effective operation and ensure their relevance.

The following key issues emerged from the debate at the Summit:

- The need for university-industry consortia to develop a shared vision that is bought into by the different partners
- The need for consortia to develop a clear articulation and understanding of the return on investment for partners, and managing expectations of what is possible
- The need for a clear route to impact, with a clear distinction between outputs and value created and captured. This may require consortia to evolve and refocus as the technologies develop, with different balances between public and private sector funding, and indeed changes in who drives the consortium forward and how decisions are made
- The need for more careful consideration of metrics to capture performance and success
- The need for more flexibility in who leads university-industry consortia. This recognised that universities do not (and perhaps should not) always have to be the hub of the consortium and that governments should be willing to invest in industry-led consortia involving universities

6 Hughes, 2011. Open innovation, the Haldane principle and the new production of knowledge: science policy and university–industry links in the UK after the financial crisis. Prometheus 29, 411–442. https://doi.org/10.1080/08109028.2011.639565

without distorting the markets. The UK's new Strength in Places Fund was cited as an interesting experiment worth following which allowed consortia of geographically proximate partners to emerge but did not dictate that universities had to be the lead partner.

- The need to better manage the scope and focus of the research and allow for flexibility over time as the research advances towards application
- The need for demonstrable university commitment to university-industry consortia, and the need for improved due diligence by both universities and companies to ensure investments are being made wisely
- The value of involving the social sciences and humanities in many technology-focused consortia recognising the insights and perspectives they can bring to public acceptance, social attitudes, regulations, incentives and the wider issues of how innovation systems need to be developed to facilitate the commercialisation of technologies
- The need to further encourage collaboration rather than competition between universities in engaging in consortia, particularly where the commercial applications of new scientific advances are less clear (e.g. in quantum technologies)
- The need to consider and clearly articulate how consortia can be, or even should be, sustained past the first round of funding. Related to this, what are the criteria that would signal that the consortium is no longer required and should be terminated?
- The need to give more thought up front to how to operationalise and implement the consortium once funding has been secured, and how to keep it relevant as it progresses
- The need to acknowledge the burden of investing in the infrastructure around consortia to enable them to function effectively

There was also a call at the Summit for public funders to recognise the time and effort required to build an effective consortium even before the bid is submitted, particularly around assembling the right combination of partners, developing a shared vision, securing real commitment and buy-in, and developing an appropriate business case with clear articulations of the value proposition and routes to impact. Pre-existing university-industry relationships that can be mobilised quickly. Where there is already a shared understanding of what they can do together the time taken to form the core of the consortium is reduced.

Government funders can take steps to mitigate these issues and raise the likelihood of effective consortia being assembled. At minimum they should give as much lead time as is practically possible between announcing any call for new consortia and the proposal submission deadline. Funders could also consider implementing a multi-stage bidding process. For example initial outline bids that meet a minimum quality threshold are awarded seed funding to develop a comprehensive business case before the full competition takes place. This approach would likely only be viable for larger consortia funding programmes and needs to be weighed against the additional bureaucracy of submitting multiple stage bids and the disappointment, and potential disengagement, of those that pass the first stage but fail at the full stage.

3.5 Opening up of company resources to facilitate more productive research engagements

Companies are also thinking about what more they can uniquely bring to university-industry partnerships to enhance the value proposition other than money and technical needs that require solving. In many sectors, large companies in particular have a plethora of facilities, data, and materials that could help to unlock new areas of research that are relevant to the needs of industry and society. Sharing these types of resources with universities often requires decisions regarding the trade-offs between the risks of opening up (such as information leakage to competitors) with the potential gains arising from more relevant and robust research being facilitated and, more trusted, longer term and productive relationships being developed.

In the biomedical space, one company provided an example of how they are experimenting with making their high throughput screening technologies and compound libraries available to academic groups seeking to advance their research into drug targets more rapidly towards identifying potential drug candidates with commercial opportunity. The results and data from these open engagements are owned by the academic to pursue as they see fit. The company's hope is that, by focusing on enabling and building productive and trusted relationships at these early stages, the academics will return to them, rather than a competitor, to commercialise promising leads.

The rise of big data, combined with significant advances in artificial intelligence and machine learning, is transforming the types of questions the research community can address. This applies across the spectrum from technical fields such as medical diagnostics to the social sciences. However a major hurdle facing such research is that much of the data is:

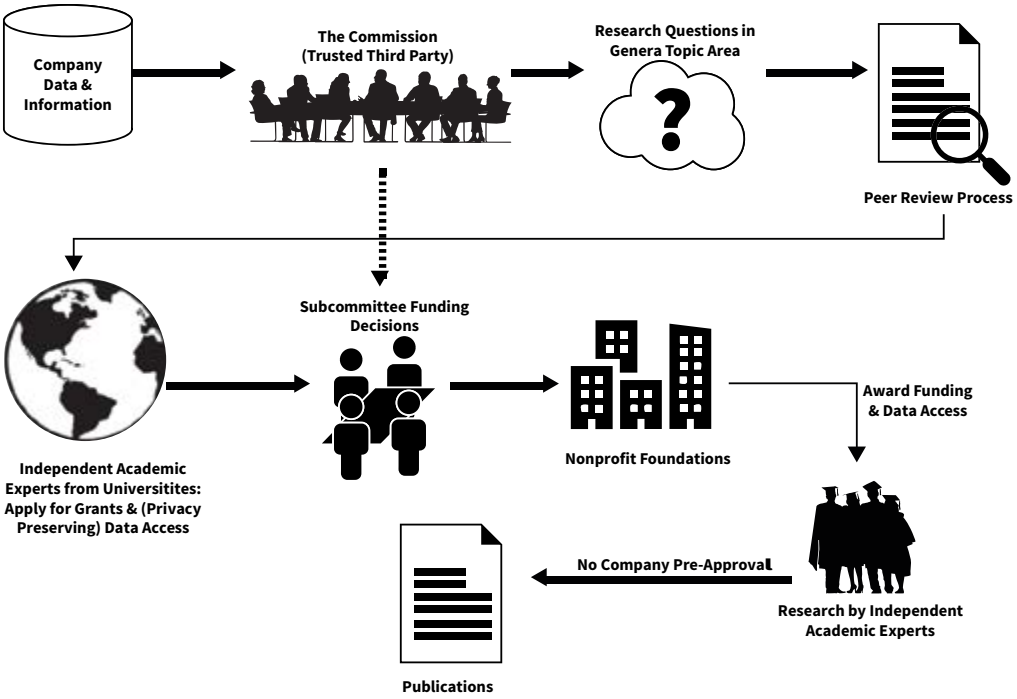
- Held by private corporations
- Highly personal or sensitive
- Subject to legal protections to maintain privacy (e.g. personal medical records, and the information on billions of consumers' socio-political habits and choices being captured by technology platforms)

Given the potential significant benefits of these data in underpinning valuable research, protocols are being developed to create secure, trusted ways of opening up these datasets to researchers.

One example is the work of Gary King (Harvard University) and Nathaniel Persily (Stanford University), which captured in their recent paper *A New Model for Industry-Academic Partnerships.* The approach is designed to develop a "mutually incentive-compatible approach [that] enables academics to analyze and use the increasingly rich troves of information amassed by companies to address societal issues, while protecting their respective interests and ensuring the highest standards of privacy and data security". In doing so, it enables companies to engage with the scientific community to help them produce social good, while protecting their interests and deliver value to their organisations. The outline of the model is shown in Figure 2. This is being instituted as Social Science One and incubated within Institute of Quantitative Social Sciences at Harvard University.

Figure 2: King, G., Persily, N. (2019) A New Model for Industry–Academic Partnerships. PS: Political Science & Politics pp. 1–7

Figure 2 Outline of the King-Persily industry-academic partnership model for sharing big and sensitive data



Notes (from on King and Persily, 2019):

The commission is formed of senior academics who sign confidentiality agreements with the companies and forego the right to publication on the basis of the data

The company and the commission jointly agree the scope of a research project and issue a request for proposals

Proposals are selected by the academic commission on the basis of academic and social merit (excluding proposals which violate privacy or existing legal agreements/obligations, infringe on ongoing investigations, or put a company at a competitive disadvantage)

Data access is provided that maintains privacy of the data

3.6 Integrating social sciences and humanities into university-industry partnerships

One of the most pronounced trends emerging from the Summit was the growing recognition of the added value that concepts, evidence, and insights from the social sciences and humanities (SSH) can bring to the variety of innovation activities of many companies. Even for those whose innovation efforts are highly technologically focused. From an innovation perspective, SSH research was seen by delegates as an underutilised and often untapped resource and that much more needs to be done to integrate it effectively into university-industry partnerships.

The NSF's Future of Work at the Human Technology Frontier provided a good example of the value of a growing convergence between, and integration of, STEM and SSH disciplines. This research operates at the intersection between the future of work, future of technology and future of workers. It requires different types of expertise and research tools and techniques from a wide range of disciplines, such as:

- Future Workers: Fundamental principles and support of individual workers, work teams, workplaces, and work organizations
- Future Technology: Engineering & computer science technologies to create human-technology work partnerships
- Future Work: Analyses of societal, economic, educational and national contexts, including benefits and risks

More broadly, the social sciences and humanities have witnessed significant changes over the past decade in both the type of research being conducted and the way it is conducted. This has been enabled in part by the rise of big, micro-level heterogeneous datasets, coupled with the development of computational techniques and power. Researchers can now both develop *and* test theoretical solutions to, for example, behavioural responses to the deployment of new technologies. Summit delegates also suggested that SSH researchers are becoming increasingly challenge focused, with an increasing shift from individual to team science approaches involving larger collaborations and teams of postdocs.

Summit delegates also reported witnessing a growth in engagement between SSH researchers in their universities with companies. A range of synergies were articulated. SSH researchers can:

- Benefit from access to datasets that are controlled uniquely by companies
- Access much larger pools of industrial R&D funding from industry than is possible through government funding agencies
- Generate opportunities for both undergraduate and postgraduate student placements
- Develop partnerships to help shape educational programmes

Companies benefit:

- Exploiting opportunities from the 4th industrial revolution. Many of the new types of economic and societal challenges require much better understanding of human behaviour and responses to change, public acceptance, and culture
- Developing new business models to create and capture greater value from emerging opportunities and adapting to significant changes facing many traditional industries
- Developing insights into business practice (e.g. how to manage organisations effectively, understanding team dynamics in challenging environments to improve performance, and understanding human motivation and behaviour in adopting new technical solutions)

When involving SSH more effectively in university-industry partnerships, it is important to recognise the power differences between the physical and social sciences. The former has much more influence both within the academy and within funders. Delegates argued, however, that it was not helpful to move to become 'post-disciplinary', but rather to better understand and recognise the respective value that different disciplines could bring to addressing societal, technical and economic challenges. This requires continued efforts to build firm foundations within specific disciplines, as well as effective bridges between them with convergence of ideas and knowledge where necessary.

The Summit delegates identified a series of actions that could be taken by university, industry and government partners to accelerate the integration of SSH into productive partnerships, including:

Universities

- Further cultural change around reward and recognition in academia, particularly in those areas of SSH that have not had a history of engagement with industry. This may require:

- Changes to tenure and promotions processes
- Changes to how appointments are made
- New career structures and pathways that are inclusive of the expertise required to effectively engage with companies

- Investing in secure data facilities to give confidence to industrial partners seeking to engage in partnership with academics as big, and increasingly sensitive and private, data becomes central to a lot of research

Businesses

- Increase understanding of the potential value SSH research can bring to the development of new products and services
- Reorient and adapt their organisations to confront emerging societal, economic and technical innovation opportunities and challenges. This includes responding to growing pressures to move beyond profits and encompass more socially and environmentally focused core motives and objectives
- Be willing to experiment with new ways of engaging with universities that involve SSH researchers

Government agencies

- Greater promotion of convergence research bringing together STEM and SSH research to address societal, economic and technical innovation challenges
- Promote the value of SSH research, particularly within the STEM research community and take steps to rebalance the power imbalances and 'siloisation' of disciplines

Professional organisations focused on building university-industry partnerships

- Develop and share insights into the value of SSH research for industrial partners
- Develop and share insights into effective practices for engaging SSH research in university-industry partnerships by reflecting on the necessary incentives, working cultures, and infrastructure and facilities (e.g. co-location space, secure data facilities) required to underpin effective engagements

3.7 Challenges in experimenting with new partnership models

Developing and implementing new approaches to university-industry partnerships requires overcoming a range of obstacles that preserve the status quo.

A well-known issue affecting the development of university-industry partnerships is the difficulty of finding the right partners. Even more so when partners want to experiment with new models of engagement which inevitably entails higher risks with the promise of higher rewards compared to existing models. This requires all of the partners involved (internally within the university and externally) to be *willing* to innovate in how they work together and organise their interactions.

Related to this is convincing stakeholders to depart from the traditional way of working and engage with the experiment. This may require engaging with a network of stakeholders, across key parts of the organisation and externally, who can become champions for the experiment. They need to buy into the vision and objectives of the new model, and be able to communicate and further sell them to their respective communities. Internal stakeholders could

include key senior decision makers; faculty leaders and the relevant research communities; and knowledge exchange support professionals. Externally, stakeholders may need to include funders, decision makers in the local innovation ecosystem, and in the partner organisations.

Strong pre-existing relationships between the initial partners, a history of working together successfully, and a prior track record of developing and implementing new models that unlock additional sources of value for partners, will all help to convince partners and key stakeholders to engage with the experiment. Furthermore, effort needs to be put into developing a shared understanding of the potential value of the new partnership model along with a realistic understanding of the expected costs, risks, and trade-offs of departing from the status quo.

In many universities and companies, it may also be easier to carry out a small-scale pilot experiment to demonstrate the potential to unlock new sources of value for the partners involved. Pilot experiments can also provide critical opportunities for learning about what does and does not work, and allow for corrective action to be taken before being scaled-up. There should be a commitment from all parties to regular reviews to facilitate learning. Those involved need to be willing both to adapt the design and terminate the project if necessary.

3.8 Moving forward

Only so many models and key trends could be explored during the Summit. Key areas where more discussion of new models and trends is needed include:

- Models of 'ecosystem' driven partnerships that bring together universities, research and technology organisations and others with complementary expertise, resources and infrastructure required to address societal, economic, technical or industrial challenges. This has the potential to strengthen the value proposition for corporates to engage
- Models of 'global' partnerships that encourage and facilitate engagement between universities in different countries and multinational corporates with a global footprint
- Models for effective sharing of sensitive data and resources which can deliver value to both academia and industry. This is particularly pressing for university-industry partnerships that would benefit from the sharing of highly sensitive, individual data to drive innovation and unlock societal value (e.g. around medical diagnostics). Models need to find ways of meeting the needs of open, objective academic research with companies' competitive, legal and ethical commitments to data security
- Models that create 'safe' spaces for dialogue between partners around very sensitive topics

4

Moving beyond traditional university-industry partners to capture new opportunities

Section 2 outlined a number of key global and national trends and drivers that are affecting both the nature of innovation and the landscape within which innovation takes place. These are creating ever increasing pressures on universities to contribute more proactively to the many and varied socio-economic, technical, and industrial challenges facing our world, nations and regions. While challenging, these trends and pressures are creating new opportunities for universities to not only deepen their partnerships with their traditional partners, but also engage more widely and involve new types of partners, for example:

- Innovative new companies that are seeking to disrupt traditional industries through the deployment of the latest scientific and technical advances – particularly in the use of artificial intelligence and big data science tools and digital manufacturing
- Established companies that have historically had little engagement with the research base other than for recruitment, which have realised the potential value from broadening their interactions to include more direct support for their innovation activities (e.g. legal services, financial services, and financial technology)
- Companies in sectors that have historically been highly conservative with respect to innovation but are now increasing their innovation efforts and capacity (e.g. construction)
- Places and local innovation ecosystems that have historically lacked significant engagement with universities (local or otherwise) to build their capability and capacity deliver economic development goals through innovation.

There was also recognition at the Summit of the focus on linking leading-edge science with leading-edge innovating organisations. However policymakers were increasingly aware of the need to strengthen the links and flows of knowledge between universities and companies further inside the technological frontier. These interactions may be better placed to facilitate technology adaptation and absorption rather than technology and innovation 'generation'.

In the UK this broadening of engagement was seen as critical if the nation is to achieve the government target of 2.4% of GDP spent on R&D in its industrial strategy. This reflects a growing realisation that this target cannot be met by increasing activity in large companies that are already R&D intensive; new sources of R&D activity in the economy will have to be developed and nurtured. Universities have an important role to play in this process.

Pursuing these opportunities and increasing productive engagement with new types of partners requires continued experimentation in models of partnership and knowledge exchange, some of which are discussed in section 3. Critically, it requires overcoming both well-established barriers to engagement with certain types of organisations (e.g. with small companies) and dealing with emerging challenges as universities and new partners develop new types of innovative products and services. The latter were exemplified at the Summit by emerging partnerships around big data and the development of artificial intelligence-driven products and services. Companies looking to develop partnerships in these areas noted that more work needed to be done around:

- How to share data securely and effectively
- How to value data appropriately
- How to establish collaborations that can deliver to the often short timescales of rapidly changing sectors and technologies

Discussions at the Summit also identified possible ways of building partnerships with companies and organisations that are not at the leading edge of technologies and innovative activity, and with SMEs. These included:

- Working through supply chains of large companies in the right field. This can help SMEs – often with little experience of engaging with universities and limited resources to identify possible partners – target the right events and conferences, facilitate access to professional and scientific networks, and identify and navigate potential collaborative funding opportunities and processes
- Relevant research and technology intermediaries (such as the Catapults in the UK, Fraunhofer Institutes in Germany, and the Manufacturing USA institutes in the US) helping their companies to navigate the research landscape and identify possible partners and funding opportunities
- Making it easier for people operating in different parts of the innovation system to meet each other and find emerging technologies that are relevant to their innovation needs
- Raising awareness amongst companies inside the technology frontier of the potential benefits of innovation, adopting new technologies, and engaging with the research base. Some delegates suggested that there were important 'network' effects of knowledge and technology transfer for companies inside the technological frontier – the more they see other companies adopting new technologies and engaging with universities, the more they are likely to do so themselves
- Indirectly, by universities contributing more proactively to the development of standards. This recognises the important role for standards in diffusing new technologies through an innovation system.

5

Developing metrics for university-industry partnering

The development of metrics for university-industry partnering has become a key topic for partnership practitioners and policymakers alike. This reflects growing pressures on them to make more effective decisions about where and how to invest effort and funding to deliver value to their organisations and stakeholders. Appropriately developed systems of metrics could support this process by providing insights into the potential for valuable partnering opportunities, and the functioning and performance of resulting partnerships.

Discussions at the Summit emphasized however that metrics for university-industry partnering need to be developed carefully and cautiously. Poorly designed systems can have unintended consequences and lead to adverse and unexpected behaviours. There was also a belief that there was no 'golden bullet' for metrics – no single metric or set of metrics would work for all organisations in all circumstances. As a result efforts should be focused on developing baskets of metrics that can be deployed as appropriate. Furthermore, there are many aspects of the functioning and performance of partnerships that cannot easily be measured quantitatively. Metrics should thus include both 'hard', objective metrics as well as more qualitative metrics based on 'softer', more 'subjective' expert assessments by those involved and influenced by the partnerships.

Metrics have the potential to inform different aspects of partnering decisions and development. Each aspect will have different evidence requirements for effective decisions. As such one has to be clear about the objective of the metrics exercise. Examples include:

- Helping to identify potential partners, including better targeting of partners and reducing search costs
- Informing due diligence of partners selection
- Monitoring performance
- Evaluating outcomes to inform learning, course corrections, and future strategic and operational decisions

Decisions take at different levels of the system will also require different types of evidence and place different burdens on ensuring consistency and comparability across projects, partnerships and organisations. For example metrics can inform the development of:

- Specific projects (e.g. to inform stop-go decisions, evaluate the success of specific investments)
- Specific partnerships (e.g. to assess added value of a partnership bringing together multiple projects over longer periods of time, and learn and adapt from experience)
- Portfolios of partnerships or projects (e.g. to inform decisions on where to increase or decrease investments, which requires comparability between partnerships and projects)
- Overall system (e.g. to inform where overall system needs to be further developed, which requires comparable evidence between organisations)

The challenge of collecting suitably defined and comparable data becomes greater as one moves up through the levels from project to system, not least because the necessary information is increasingly held and owned by units and organisations further outside the sphere of influence of the group or organisation developing the metrics.

Given this, it is inevitable that different stakeholders in the university-industry partnering community will have different requirements for metrics and evidence. For example:

- Practitioners directly involved in specific partnerships making partnership-specific strategic and operational decisions
- Leadership in universities and companies with interest in the overall portfolio of partnerships
- Policymakers developing and evaluating funding programmes

The remainder of this section will focus on developments in three key areas: (i) metrics for universities and companies to make more informed and strategic partnering decisions; (ii) metrics to evaluate the performance of specific partnerships; and (iii) nation-wide metrics systems.

5.1 Metrics for universities and companies to make strategic partnering decisions

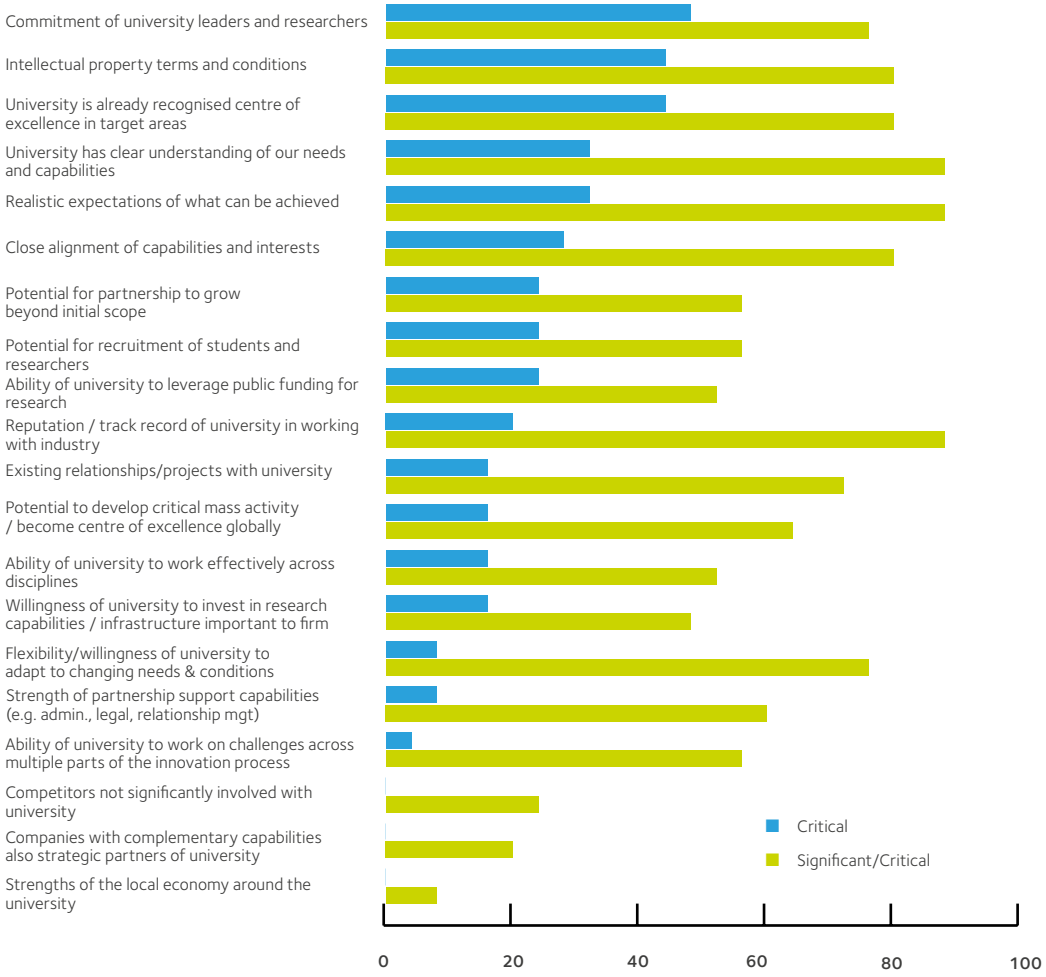
A key demand for new metrics centres on the pressures facing universities and companies to make more strategic and effective decisions on who to partner with. In many organisations finding the 'right' partner was often driven by insights gained through social and professional networks as well as the past experiences of staff (often in the universities they attended as students), and ad hoc evidence available to the team. Larger organisations may have the resources to mine publications datasets, patents and other data sources, or invest in technology scouts and horizon scanning exercises. These options are however not typically available to smaller or less experienced organisations. Even within large organisations with long histories of university engagement which are able to undertake these partner search activities, there remain concerns that they are missing opportunities for valuable interactions because they are not fully aware of the research base. These concerns can be particularly acute if companies have many options for interactions with academics (e.g. they are one of a small number of technology leaders in a sector and are approached by many to engage).

Responding to this growing need organisations have been investing in developing big data and data science driven tools targeted at the partnering community. These typically aim to make it easier for universities and companies to identify potential partners by generating more valuable insight through structuring and linking different datasets (e.g. publications, grant awards, patents) which capture who is doing what in the research base with an aim. Data-driven companies active in this space include companies such as Elsevier, Clarivate Analytics, In-Part and Digital Science, membership organisations such as the UK National Centre for Universities and Business (through its Konfer platform), and funding agencies such as Knowledge Transfer Ireland (providing access to technology, expertise and funding through its web portal), UK Research and Innovation with its Gateway to Research, and the US Federal RePORT system managed by STAR Metrics (covering research grants provided by multiple US funding agencies and government departments including the NIH, NSF, NASA and DOD).

However while there have been significant advances in helping companies pinpoint expertise within the research, we still lack systematic evidence to inform due diligence around partner selection. Figure 3 presents the findings of a survey of large companies that have experiences in forming strategic university-industry partnerships on the factors influencing partner choice. What is clear from this survey, and from the broader literature on the factors underpinning effective partnerships, is that partner choice is shaped not just by the potential to create value in a technical area relevant to the organisation, but also by whether the partners are likely to be able to work effectively together to capture value from the interactions.

Figure 3: CSTI 2015 survey of large, product-driven companies involved in strategic partnerships, N = 25

Figure 3 Factors influencing a company's choice of university as strategic partner



Existing metrics provide little insight into most of the top factors driving partner choice. A key challenge is that many of the factors behind the ability to create and capture value through partnerships are very hard to quantify. For example what metrics could capture being able to build effective and trusting working relationships between the people, securing commitment and buy-in from relevant internal and external stakeholders, and being able to align objectives and expectations?

More work needs to be done to try and develop effective metrics – quantitative or qualitative – that can capture the variety of factors influencing partner choice, such as how well universities:

- commit to and support partnerships with companies
- enable partners to realise and capture value

Developing insightful metrics and estimates of 'returns on investment' were thought much harder for partnerships focused on lower 'technology readiness level' activities (i.e. more fundamental and early stage research). Sometimes company managers just have to be able to take an informed risk with specific investments and focus more on learning and adapting as projects and partnerships progress.

5.2 Metrics to monitor and evaluate performance of university-industry partnerships

Universities, companies and funders have long been interested in understanding whether or not their investments in partnership development are performing well and generating positive and successful outcomes. The ability to monitor performance and evaluate impacts depends critically on the availability of good and robust data, as well as an understanding of how the investments lead to impacts.

Logic models (such as that developed by the Kellogg Foundation[7]) can provide a useful structure to guide the collection of data to inform these efforts. Crucially, logic models force evaluators to identify a clear rationale and objectives for the investment, and distinguish between the planned work (including both the inputs required and activities enabled by them), the outputs produced (such as technical reports, patents, trained staff) and the effects these outputs ultimately have on the organisation and wider system. In addition, any evaluation of the performance of investments in partnerships should reflect on the 'counterfactual' of what outcomes and impacts would have been realised in their absence (often referred to as 'additionality' of impacts).

Figure 4 Evaluation logic model

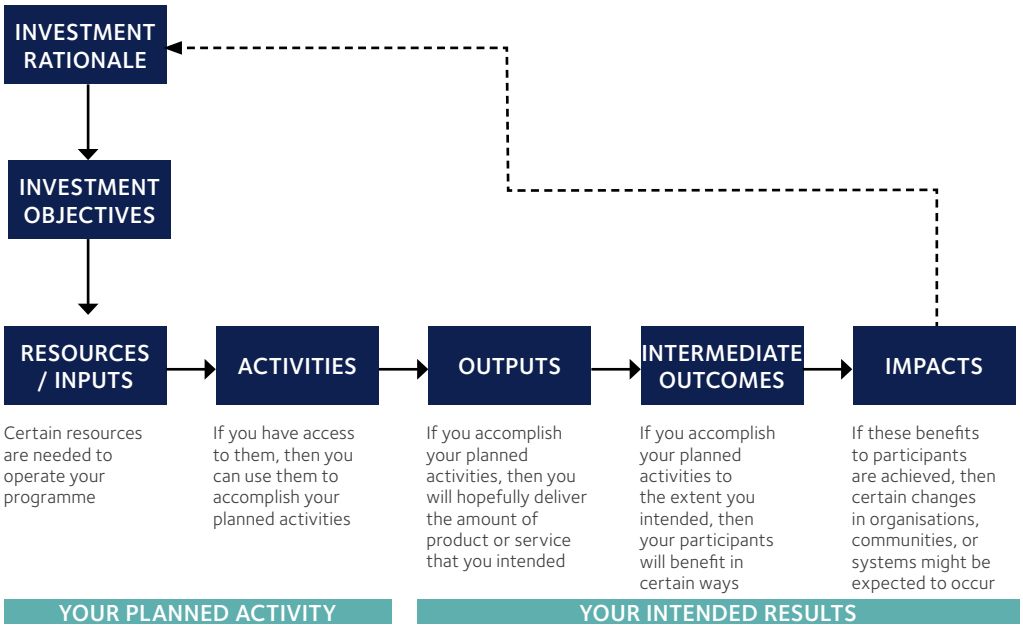


Figure 4: adapted from Kellogg Foundation, 2004. Logic Model Development Guide. W.K. Kellogg Foundation, Michigan, USA.

The Summit explored some recent developments by companies and organisations such as the UIDP in metrics systems to inform assessments of partnership performance.

In 2017 the UIDP published a Collaboration Metrics Guide drawing on the experiences of their diverse set of university and industry members in developing practical metrics that capture the performance of individual strategic university-industry partnerships. It was recognised that many universities and companies find conveying the value and quality of partnerships exceedingly difficult. The resulting guide provided individuals within universities and companies with a menu from which they could select a set of metrics appropriate to their specific objectives and context. The aim is to enable organisations to paint a picture of whether partnerships: should be nurtured; have opportunities to grow; and whether or not partnerships should become strategic. The collaboration metrics menu is closely linked to the types of engagement identified in the Partnership Continuum framework developed by UIDP in 2012[8].

7 Kellogg Foundation, 2004. Logic Model Development Guide. W.K. Kellogg Foundation, Michigan, USA.

8 UIDP, 2012. Partnership Continuum: Understanding and Developing the Pathways for Beneficial University-Industry Engagement. University-Industry Demonstration Partnership, Washington, D.C., USA.

Figure 5 Features exhibited in multi-faceted relationships between universities and industry partnerships

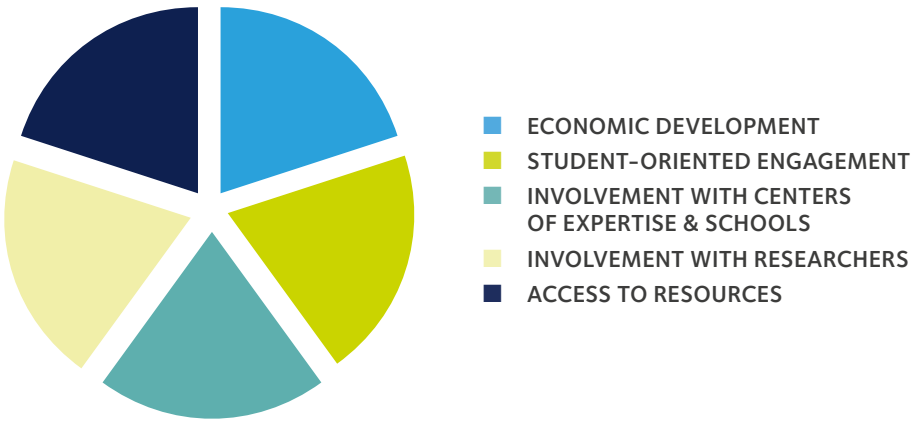


Figure 5 Source: UIDP, 2012. Partnership Continuum: Understanding and Developing the Pathways for Beneficial University-Industry Engagement. University-Industry Demonstration Partnership, Washington, D.C., USA.

The Summit also gained insights from companies with significant of university-industry partnerships on the development of metrics to capture partnership performance. Key messages included:

- Metrics need to be tailored to your stakeholders and be part of a narrative – those that are important to one stakeholder may not be important to another. This also highlights the importance of understanding the needs and motivations of the different stakeholders involved.
- Organisations should care about metrics that matter to their partners, not just about those that are of value to themselves. This recognises that successful partnerships need the ongoing support and commitment of all partners involved. Those involved within universities will benefit from helping their counterparts within companies demonstrate the value of the partnership, and vice-versa.
- Some factors that are important drivers of successful partnerships are very hard to measure but nevertheless need to be captured (e.g. the strength of the working relationship and trust between partners). This once again emphasized the need for metrics systems to bring together quantitative indicators and qualitative and expert assessments by those involved and influenced by the partnerships.
- Metrics need to focus on assessing outcomes and impacts not just inputs. Too often metrics focus on counting inputs, activities and outputs. These say little about whether the partnership is having any effect on the organisation. It may be produce many technical reports and patents, but they may not be generating any value to the partner organisation! While these can be very hard to quantify, there are established methods, for example surveys and interviews with beneficiaries that can provide valuable insights on the outcomes and impacts being realised.
- Metrics benefit from being incorporated into an overall narrative. These can help to bring the partnership 'alive' with real examples of activities taking place and how they are being translating into benefits for those involved and more widely. Narratives can also provide insights into the specific rationale for engaging with a particular partner that can be hard to capture through metrics alone. Ultimately, narratives backed up by key metrics can provide a much more persuasive case than metrics alone.

5.3 Nation-wide metrics for university-industry partnering

Governments and national organisations in the US, UK, Ireland and a number of other European countries have been attempting to strengthen the availability of data on university-industry engagements across their university system. Examples include:

- UK: the Higher Education Business and Community Interaction (HEBCI) managed by the Higher Education Statistics Agency[9]
- US: the Association of University Technology Managers Statistics Access for Technology Transfer (STATT) Database[10]
- Ireland: the Knowledge Transfer Survey managed by Knowledge Transfer Ireland[11]
- Europe-wide: the survey report on Knowledge Transfer Activities in Europe assembled by ASTP[12]
- Australia: the National Survey of Research Commercialisation managed by the Australian Government's Department of Industry, Innovation and Science[13]

Table 2 Coverage of selected nation-wide datasets relevant for university-industry engagements

	AUTM USA/Canada	HEBCI UK	ASTP EU-wide	Australian Gov't NSRC	KTI AKTS Ireland
Disclosures	✓	✓	✓	✓	✓
Patenting	✓	✓	✓	✓	✓
Licensing	✓	✓	✓	✓	✓
Start-ups/ spin-outs	✓	✓	✓	✓	✓
Industry collaboration	✓	✓	✓	✓	✓
Research expenditure	✓	✓†	✓	✓	✓
Revenue	✓	✓	✓	×	✓
Other	Products, active start-ups	Consultancy, contract research, collaborative research, facilities and equipment services, training, regeneration programmes, active start-ups/ spinouts, jobs/ turnover linked to start-ups/spinouts	Consultancy, contracts	Consultancy, contracts, commercialisation staff, training	Consultancy, contracts, products, active start-ups, jobs, facilities access, incubation
N =	USA 193 Canada 34	16	475 27 Countries (5 national data sets = 80% of data)	63	26

† Available by linking HEBCI with a related Higher Education Statistics Agency Finance Record dataset
Source: reproduced and adapted with permission from Alison Campbell

9 https://www.hesa.ac.uk/collection/c18032
10 https://autm.net/surveys-and-tools/databases/statt/
11 https://www.knowledgetransferireland.com/Reports-Publications/KTI-Review-and-Annual-Knowledge-Transfer-Survey-2018.pdf
12 https://www.astp4kt.eu/resource-center/publications/
13 https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation

These datasets typically provide data at the university level with differing degrees of coverage across technology transfer and university-industry engagement activities (Table 2). These datasets have proven incredibly valuable, particularly for policymakers and university leaders in technology and knowledge transfer, not least through their ability to:

- More robust assessments of the diversity and strength of the national and regional landscape for technology and knowledge transfer
- Identify key trends in different modes of engagement of technology and knowledge transfer
- Link data with other secondary datasets or surveys, and explore factors driving different types of engagement and outcomes
- Provide an evidence base for policymakers to allocate funding for technology and knowledge transfer (in the UK)
- Develop evidence to inform the business cases for public funding programmes
- Benchmark university activity and performance in technology transfer and university-industry partnering to inform strategic, university-level decisions on technology and knowledge transfer

However, this type of historical data typically struggles to provide the necessary insights to inform university and industry partnership practitioners' decisions about partner selection or the evaluation of partnership performance. Key limitations that hamper its use in these areas include:

- An inability to drill down below the university-level to capture activity at more granular and relevant levels for businesses
- Limited evidence on engagements with particular sectors or technologies
- Limited ability to make international comparisons
- Some types of important engagement mechanisms are typically not captured (e.g. multi-faceted strategic partnerships)
- Limited insights into the value of partnerships
- Limited insights into the risks and transaction costs of engaging with a university – this is a particular challenge as it will be dependent, in part, on prior experience of working together

In response, national-level organisations and governments have been looking at whether their system-wide metric systems can be revised and strengthened to help universities and companies make more informed and evidence-based decisions on partnering. For example the UK government asked its university funding body, Research England, to develop a 'Knowledge Exchange Framework' (KEF)[14], the metrics component of which will provide:

- HEIs with a useful source of information and data on their knowledge exchange (KE) activities, for the purposes of understanding, benchmarking and improving their own performance.
- Users (and potential users) of HEI knowledge with another source of information, which may increase the visibility of potential university partners and their strengths, and thereby contribute to internal decision making processes.

Critically, while the first iteration of the KEF will focus on using existing data more effectively, the ambition is that it will inspire new metrics and data sources to be developed with full coverage across the UK university system and adapt accordingly.

The process of developing nation-wide metrics systems itself can bring significant benefits. If undertaken in an inclusive manner involving the range of key stakeholders, it has the potential to improve consistency of variable definitions and data collection methods,

14 https://re.ukri.org/knowledge-exchange/knowledge-exchange-framework/

and bring the community together to examine and debate how to capture the variety activities, outputs and impacts associated with technology and knowledge transfer.

However, one must also approach nation-wide metrics development with some caution as it has the potential to drive behaviours on the ground, and can lead to unintended and possibly adverse consequences. This suggests that any new metrics should be consulted on with key stakeholders and piloted before full scale implementation.

Discussions at the Summit were clear that there is generally much more detailed evidence available on technology licensing and university spinouts than on the wider variety of university-industry partnering activities. Delegates highlighted interest and efforts to reflect on what data is collected on these broader activities in a range of countries. Combined with the growing importance of partnerships for universities, companies and policymakers and the desire for those involved to be able to make international comparisons in this area, it would appear timely to bring together the different national efforts to explore the potential to develop a more standardised and internationally comparable set of metrics for university-industry partnering.

6

Data-informed decisions for partnering and issues of artificial intelligence

As with other areas of innovation, university-industry partnering practitioners are becoming interested in how they can benefit from the rise of big data and the suite of associated artificial intelligence, machine/deep learning and other data science tools. This was a key topic of discussion at the Summit.

The rise of big data and data science tools have the potential to contribute to university-industry partnerships through:

- Identifying partners and informing decision-making
- Improving monitoring and evaluation of partnership activity and outcomes
- Raising new types of research questions which address novel innovation challenge
- Unlocking new ways of working and learning

However, it can be challenging to innovate with big data/data science tools and experiment with how universities work. Delegates noted that, as typically very large and complex organisations, universities can be risk averse to trying new ways of delivering and supporting research, education and partnering, with any systemic change likely to slow and cumbersome. This was complicated in many instances by the lack of individuals in university leadership roles who fully appreciate the variety of benefits, as well as risks and complexities, that could be realised from developing and deploying these types of tools.

Engaging in partnerships that focus on developing big data, AI and data science solutions to innovation challenges also create new types of barriers that have to be overcome, for example:

- How to access and share highly sensitive data whilst protecting the legal and ethical obligations of companies to protect the data maintain an individual's privacy
- How to appropriately value data
- How to appropriately value and protect AI and data science based technologies emerging from partnership activities
- How to engage effectively with AI/data-science driven companies operating in fast moving sectors, which typically require highly responsive partnerships, quick turnaround of projects and rapid deployment of any advances made

6.1 Ethical implications of the development and deployment of artificial intelligence

The capabilities of AI-based tools are developing at a rapid rate and are starting to be used to inform decision making in different areas, perhaps most prominently in healthcare and insurance. As their potential power to influence and transform society becomes clearer, a wide range of stakeholders are raising important concerns about the ethical implications of using such tools, particularly as part of any decision-making. Ethical issues highlighted at the Summit include:

- Privacy
- Algorithmic accountability
- Transparency and explicability of decisions
- Ability to contest decisions
- Potential for reinforcing societal biases

Addressing these ethical implications is critical as the effective deployment of AI-based tools for decision-making will depend not just on their accuracy but also on whether they are trusted and accepted as legitimate by those stakeholder groups affected[15]. Crucially, these issues appear to vary by the context and sector within which the decisions are being made. For example, research by the UK's Information Commissioner's Office in collaboration with the Alan Turing Institute found that people are much more willing to accept a medical diagnostic decisions based on AI without an explanation of the algorithm's accuracy, than recruitment-decisions[16].

Summit delegates also raised an important question on the role of AI-driven tools in decision-making. Do we want to make AI-driven algorithms the domain expert and effectively replace humans in making decisions, or develop AI to augment the ability of humans to make more effective decisions? There were calls to harness the knowledge of experts through AI and help them to institutionalise their knowledge more effectively; and to develop an AI ecosystem that drives dialogue between affected stakeholder groups.

There were also calls from delegates to place ethical issues and implications of the use of AI in decision-making at the heart of the development of the technology and product not an afterthought once the tool has been developed. This raised broader questions of how to drive and reward responsible innovation which manages risks and uncertainties. Responsible innovation is collective, participative and inclusive of the different stakeholders that will be affected by the innovation. In this context, it would include researchers (public and private sector) from different disciplines (bringing together technologists with social scientists and ethicists), government agencies and regulators, the public, and others. It would attempt to anticipate key ethical issues and develop a system for trying to deal with them as the research develops and technologies emerge.

15 ICO, 2018. Big data, artificial intelligence, machine learning and data protection. Information Commissioner's Office.

16 ICO, 2019. Project ExplAIn: Interim Report. Information Commissioner's Office.

Universities, through their partnership with industry, should be at the forefront of developing and demonstrating approaches to responsible innovation for technologies built on AI that include ethical considerations from the start. It should also be incumbent on researchers in all fields to consider and reflect on the purpose, motivations and consequences of their research.

There was also a recognition at the Summit that we need to be agile and adaptable, as AI technologies and our understanding of their potential to drive decisions, behaviours and ultimately shape societies, is still emerging. As such our understanding of the ethical implications and appropriate responses to ensure the responsible use of AI is also evolving. However, innovators are not going to stand still in this area. There were thus calls for new efforts and investments to examine and address the ethical implications of deploying AI in decision-making. This was seen as critical to help build public trust and acceptance in this technology.

Whether or not to regulate, and when to do so, are always challenging questions for an emerging technology. Some suggest that regulating such technologies will stifle innovation, while others argue it will improve practice, help to create a level playing field, and help to build public trust in the deployment of the technology. This is particularly true of AI given the ethical issues it faces of privacy, transparency, accountability and the potential to significantly affect personal empowerment. As ever, where delegates were in favour of regulation, there were calls for effective, not burdensome, regulation. In particular it should allow for different practices and approaches in different sectors and application contexts, and must allow for experimentation.

This then raised the question of how regulatory approaches can deal with honest mistakes and failures that are inevitable in the innovation pathway of an emerging technology. If the regulatory route were pursued, regulations should emphasize processes of learning and improvement following failures and mistakes rather than – *within* reason – focusing on punitive measures and attributing blame. Ultimately, however, it was recognised that regulation alone would not be sufficient to ensure that AI-driven tools were developed and deployed in an ethically responsible way.

Lastly, given that we are in a period of immense change in how decisions are being made, it was felt critical that we learn carefully and cautiously from early adopters of AI-tools in decision-making. Healthcare and insurance sectors are at the forefront of these debates and will provide valuable insights and lessons for other sectors looking to follow suit.

7

National R&D targets: helpful or misguided?

R&D intensity – measured at the national level as the proportion of R&D expenditure in GDP – is commonly used as an indicator within science, technology and innovation policy. This reflects the belief that increased R&D in an economy drives innovation, economic growth and ultimately prosperity. It is frequently used for international comparisons of the innovation potential of countries. Given the importance policymakers attach to R&D as a driver of innovation and economic growth, it is perhaps unsurprising that many countries, and in particular those nations and regions that exhibit lower-than-average R&D intensities, set targets to drive up the amount of money spent on R&D. In the UK R&D intensity stands at just 1.7% of GDP in 2017, behind the European Union (28 country) average of 2%, the OECD average of 2.4%, 2.8% in the USA, 3% of Germany, and 4.6% of South Korea[17].

Responding to the R&D expenditure deficit, the UK as part of their recent industrial strategy set a target of achieving 2.4% R&D intensity by 2027[18] and 3% in the longer term. The EU as part of its Lisbon strategy observed an R&D intensity deficit compared with countries such as the US and Japan, and accordingly set a 3% R&D intensity to be achieved by 2020[19].

But how important are national R&D targets for improving innovation and economic outcomes? A key message from the Summit was that such targets focus on a specific type of innovation for which R&D is a critical input. Evidence shows, however, that much valuable innovation activity, particularly outside the traditional manufactured product sectors is not based on R&D (as typically defined) but rather on other types of knowledge-based activities and inputs. Similarly, incremental innovation can be deliver significant value to companies and is typically much less R&D intensive20, 21, 22.

A broad framework is required to strengthen the wider conditions for innovation; ensure the complementary investments required to realise value from R&D are in place; and incentivise innovative activity in less (and non-) R&D intensive sectors. Reliance on R&D targets in the absence of such a framework is likely to fail to generate the anticipated improvements in innovation and economic performance. Worse it may divert government investments to areas that are highly R&D intensive, but may not be the most efficient in terms of generating positive and broad improvements in economic prosperity.

The Summit heard from the experience of the Netherlands in trying to deliver their 2.5% R&D intensity target – set in 2011 – by 2020. It provided a clear example of how R&D targets alone are insufficient to deliver improvements in national innovation performance.

The Netherlands has evolved its approach to industrial policy since the Second World War. An active approach to policy during the period 1945-1970 switched to one that was more defensive in the following decade. The 1990s saw a primary focus on market liberalisation before shifting emphasis to a 'strong-business-strong government' approach in the first decade of the 21st Century. This then gave way in 2010 to focus on 'top-sectors' and mission-driven policy.

The most recent incarnation of their enterprise and industrial policy aimed to achieve increasing innovative capacity for productivity growth and competitiveness, and provide solutions to key societal challenges. It included three core elements: (i) a generic track to create space for

17 Source: OECD Main Science and Technology Indicators (MSTI) Dataset (August 2019)

18 HM Government, 2017. Industrial Strategy: Building a Britain Fit for the Future. HM Government, London, UK.

19 European Commission, 2010. Europe 2020: A strategy for smart, sustainable and inclusive growth. European Commission, Brussels, Belgium.

20 Arundel, A., Bordoy, C., Kanerva, M., 2008. Neglected innovators: How do innovative firms that do not perform R&D innovate? : Results of an analysis of the Innobarometer 2007 survey No. 215 (INNO-Metrics Thematic Paper). MERIT

21 Khosla, S., 2018. Reevaluating Incremental Innovation. Harvard Business Review 96, 22–25.

22 Mazzucato, M., 2010. The limits to the 3% R&D target in Europe 2020: the roles of institutions, industries, and business-government complementarities in achieving equitable and stable growth (FINNOV Position Paper).

entrepreneurs to innovate; (ii) a targeted 'top-sector' policy to strengthen the performance in key strategic sectors of their economy; and (iii) a focus on venture and seed capital finance. Within this policy a number of key targets were set, including achieving a top 5 position in the Global Competitiveness Index by 2020, and 2.5% spend on R&D as a share of GDP.

The 'top-sector' approach aimed to make the triple helix work, by joining the forces of business, research institutions and government more effectively to increase the future earning potential of citizens and contribute to key societal challenges. Nine top-sectors were selected based on high productivity, high knowledge-intensity, export-orientation, and an ability to provide solutions to societal challenges.

Critically the approach sought to incentivise not just *demand-driven* research and innovation activity, but also:

- Improve the links between public and private sector research
- Strengthen international links and opportunities through R&I cooperation and exporting
- Build up of human capital through improving links between education and the labour market
- Reduce sector-specific regulatory impediments

When looking at the performance of the Netherlands over the period 2013–2017, it increased its Global Competitiveness Rank from 8th to 4th. What remained largely unchanged was its overall R&D intensity, rising by just 0.06% over the period from 1.93 to 1.99, with almost no change since 2014. What did increase, however, was the proportion of R&D undertaken by the private sector, and the influx of technical graduates into the country. Critically, the scale of public-private partnership projects doubled over the period from €622 million to €1.25 billion, with the private sector contributing an increasing share (46% in 2017 up from 35% in 2013).

Reflecting on their experience, a review of the policy approach concluded it has enabled:

- More demand-driven programmes to be delivered
- Critical mass and momentum to address sector-wide obstacles hampering innovation effort
- Creation of a platform for collaboration on knowledge development and application within each top-sector, as well as collaborations between top-sectors.
- International branding of the top-sectors and increased trade volume in some areas

It also identified areas where improvements could be made, including:

- Closer linking of the top-sector policy approach to societal challenges and reinforcement of collaborations between government ministries
- Closer integration of the top-sector policy with existing policy instruments
- Challenging researchers and businesses to further develop cross-sectoral projects on societal challenges and involve players that are not part of the existing innovation ecosystem
- The need to strengthen the role of government as a 'launch' customer for innovation
- Improve collaborations with the regions and universities of applied science
- Simplify governance and improve transparency

There is also now an increasing prioritisation of investing in the development of key enabling technologies within the top-sector policy.

Overall, the Dutch experience suggests that the country has done well in various global rankings of innovation and competitiveness despite a relatively low and unchanging national R&D intensity. There was a suggestion that the volume of R&D was not the important driver of improving innovation and economic outcomes, but the quality and strength of the innovation system in not just generating new knowledge, but also in diffusing and exploiting it.

8

University-industry partnering and the emerging roles of intermediaries

Governments around the world have, over recent decades, been investing in research and technology organisations (RTOs) to act as 'intermediaries'. These typically seek to bridge the organisational, intellectual and capability gaps between universities and innovating organisations in the private sector; smooth the flow of knowledge; and the development of technologies from the research base into socio-economic applications. Examples include the Catapult centres in the UK, Fraunhofer institutes in Germany (and increasingly internationally), and the Manufacturing USA institutes in the United States. Summit speakers argued that a key success factor for many of these RTOs is the ability to form effective links with companies as well as universities.

As countries establish these types of research and technology organisations, policymakers and the university-industry partnering community are asking important questions about the role these new entities can and should play in the innovation system in light of the functions existing organisations already provide. Furthermore, how can any new organisations in this space form effective links with companies and universities *that add value to*, rather than disrupt and displace, existing university-company partnerships.

The Summit heard from the experiences of the USA, Germany and the UK in developing RTOs. These discussions reflected on the many and varied roles of RTOs in the innovation system. Perhaps most well-known are their provision of technical problem solving and applied research services for industrial partners, and helping to bridge the gap between academic research and industrial application in the commercialisation of emerging technologies.

Critically, discussions at the Summit emphasized that addressing industrial and societal innovation challenges, and enabling companies and nations to capture value from their investments in R&D, often involved much more than solving technical challenges and advancing technologies through the development pipeline towards practical application. A range of other bottlenecks may need to be addressed and alleviated (for example workforce development, demonstration and testing infrastructure, and regulations) to facilitate the successful deployment, commercialisation and diffusion of a technology into the economic system. The RTO examples discussed at the Summit highlighted the variety of functions they perform including:

- Undertaking the applied research necessary to bridge the gap between academic research and industrial application and enable technologies to move more effectively from idea to market
- Providing technical problem solving services for companies
- Developing the workforce of companies and their supply chains to be able to absorb and deploy the emerging technology
- Developing new tools and techniques to produce the new product or service
- Developing new facilities and infrastructure to demonstrate and test the new technologies, or to incubate new types of companies
- Developing new standards and regulations
- Helping to nurture what can often be nascent markets and working with existing companies o help them understand the potential for novel technologies emerging from the research base
- Developing market intelligence and benchmarking to inform the overall strategic direction of the sector

- Helping to build and strengthen otherwise weak links between relevant organisations in the innovation system
- Better connecting the innovation needs of companies with the latest technological and other advances emerging from the research base
- Supporting SMEs in navigating funding landscapes and funding application processes
- Supporting SMEs in accessing key export markets

In addition, the experiences of the RTOs at the Summit suggested that much of their work typically takes places with partners in relatively close proximity (e.g. from within their region). They therefore play important roles in regional cluster development and in helping to strengthen their local innovation systems to both generate and capture value from investments in local research and technology development. Indeed some of these RTOs have explicit objectives to address regional priorities.

Discussions at the Summit also highlighted key insights and lessons for governments looking to set up new RTOs to act as intermediaries in innovation systems. These included:

- Ensure RTOs are being driven by the innovation needs and challenges of industry
- Give new intermediaries time to develop – the experiences of Germany and the Fraunhofer institutes is often invoked when governments are looking to invest and design RTO models. However, people often forget that the Fraunhofer institutes have been around for many decades and the German innovation system has developed accordingly
- Develop strong relationships with universities and other research institutes, key companies and their supply chains, to enable effective transition of knowledge and technologies emerging from the research base into applications in industry and society
- Develop a strong branding for the RTO network so that companies, universities and others gain an awareness of their roles and what functions and services they provide
- Recognise that new intermediaries may not always be the right answer to addressing the key gaps and bottlenecks in the research commercialisation process
- Reflect on, and design in, long-term funding sustainability from the outset

9

Diversity in university-industry partnering: difference is beautiful

"Difference is beautiful, inclusion is possible – may we never forget that"

A common theme in many of the sessions at the Summit was the value of building diverse teams at the heart of university-industry partnerships. Earlier sections of this report have documented the growing recognition of the importance of diversity in terms of engaging with academics and researchers outside the traditional science and engineering disciplines, and the value that the social sciences and humanities can bring to partnerships.

Discussions at the Summit broadened to emphasize the value of embracing diversity in all its forms – including disability, gender, ethnicity, and age – for the building of effective university-industry partnerships. Crucially, diverse teams bring different perspectives to the problems being addressed as well as increased creativity, leading to improved outcomes.

In building more diverse teams, the Summit heard from experiences of one industry leader with a disability. She highlighted that, as a society, we are on the cusp of change. However, this is exactly the time when the momentum of change needs to be maintained to ensure that real acceptance of diversity and recognition of its value in delivering positive outcomes is cemented in the workplace. She offered some key insights and lessons for those looking to embrace diversity and build more diverse teams, including:

- Disabled people should be seen as neither tragic nor inspirational, at least not all the time. Of course there are situations when those with disabilities are truly inspirational, but this needs to be set in right context. Disability needs to become normalized such that it is no longer a barrier to employment, entrepreneurship, the ability to access venture capital funding etc. There is a concern that if we keep describing disabled people as 'superheroes' for achieving, for example, simple daily tasks, then we keep normality out of grasp.
- Language is very important. Most sources will use the word 'suffers' when referring to a disease like multiple sclerosis or chronic fatigue syndrome. Yet suffering does not define the majority of the speaker's life experience and it is not the most significant part of her life. This label does, however, have the potential to assign a negative value to an individual in the eyes of wider society. This in turn may have significant implications for decisions as they become increasingly driven by AI-based algorithms.
- Diversity should not be limited to gender and sexuality, or even disability – although these are all very important. As a community we need to look at the intersection of people's identity which covers mental health, personality, age, sexual identity etc. Organisations benefit from being able to draw on all of these things and use them in their business planning and customer understanding as well as maximising the potential of their workforce.

The speaker also emphasized the longstanding issues around unconscious biases in decision-making. In particular she highlighted the concerns and dangers around the growth of artificial intelligence in the process further reinforcing these biases rather than breaking them down. One significant issue here is that the accuracy of AI-based decision-making algorithms relies on the quality and accuracy of the data inputted. If the (often unstructured text) data itself is inherently biased,

"One of the best things about this conference is it's small. So it's a way to share information in a casual environment where we can talk openly and candidly with one another."

Coleen Burrus, Princeton University

for example in how it refers to particular classes of worker, medical condition, gender or ethnicity, then the algorithms may well lead to biased outcomes. Another issue that has to be confronted is the potential for any unconscious biases of the developers feeding its way into the design of the algorithm itself. Many algorithms are not transparent or clearly explainable. As such it is very difficult to scrutinise them for the potential for unconscious bias. As discussed in section 6, social scientists and humanities expertise has a crucial role to play here in helping to understand the potential for both conscious and unconscious bias, and inform approaches to tackling it.

In planning this Summit, the Programme Committee established an explicit gender diversity target to have fifty percent of all speakers being women. Member of the committee took responsibility for individual sessions and the overall balance was monitored at the regular teleconferences. In reality we fell short of this ambition, with just over a third of speakers being women. Furthermore, while some sessions were more evenly balanced than others in terms of gender diversity, there were still seven all-male sessions (just under a third of all sessions). If we now exclude session chairs who moderated the speakers' discussions, the proportion of female speakers falls to just under a third and the proportion of all-male sessions in total rises to nearly a half.

Reflecting on some of the reasons behind our failure to meet our ambitions on gender diversity, we found that given the scale of the Summit, with almost 80 speaker slots to fill, as we got closer to the Summit date pressures to fill slots outweighed the ambition to maintain gender diversity. Drawing from senior roles and predominantly sectors with a history of university engagement, meant the underlying representation influenced the range of potential speakers but does not excuse the imbalance.

In a number of cases we engaged with senior female thought leaders early on in the process of securing speakers but following their commitment to participate at the Summit, they then delegated to a male speaker to contribute on the day. Some declined an invitation to speak due to childcare commitments, even though provision in Oxford was offered. More broadly the duration and timing in the school holidays led to a number of possible delegates being unable to attend due to annual leave. The alignment with the political cycle was also not ideal, leading to fewer representatives from the government strand of the triple helix attending.

These factors should all be taken in to consideration in any future events as we work with the Summit community to increase the diversity of global businesses, top universities and government and enjoy the benefits that brings.

10

Delivering a pipeline of talent and increased people mobility

Developing the talent pipeline

A key concern for many companies is how to access and develop the pipeline of talent to meet their short, medium and long-term skills needs to successfully innovate and compete. This is becoming particularly acute in some skills areas, not least in those sectors experiencing rapid and significant changes to key 'platform' technologies as these underpin product, process and organisational innovation, and ultimately driving competitiveness.

A prime and current example is the rapid growth in companies exploiting AI and data science to develop new or significantly enhanced products and services, and transform the production processes and business models necessary to deliver and capture value from them. These technologies have transformed in recent years from a digital technology to a 'key enabling technology' that has the potential to unlock value across many industries and across product, process and organisational innovation. However, this rapid shift has seen nations face significant challenges in training the numbers of computer and data scientists required to meet industrial demand for these skills. Furthermore, with demand for such skills massively outstripping supply, organisations not at the technological frontier of AI/data science technology development – here largely the 'tech giants' – face significant barriers in acquiring these skills. This limits their ability to benefit from these technological advances and hampers the diffusion of these key enabling technologies throughout the economy.

Universities in many countries are often one of the key institutions tasked with delivering the pipeline of highly skilled labour into the labour market. Much attention is on undergraduate education, with calls at the Summit for curricula to become more agile and responsive to the longer-term skills needs of the economy and society.

However, in developing the pipeline of talent, the career trajectories of the academic researcher community post-PhD is often overlooked. With the numbers of doctoral students increasing, and the numbers of postdoctoral researchers significantly outweighing the number of available jobs in academia, the reality is that most will end up in non-academic jobs in the private, public or charitable sectors. This creates a significant challenge for the many doctoral students and postdoctoral researchers whose early ambitions are to become tenured academic staff.

It also represents a significant opportunity. The Summit heard from the experiences of a recent study by the League of European Research Universities (LERU) on the careers of researchers inside and outside academia[23]. It identified a number of key changes in the economy and the way innovation is conducted that are creating new, exciting and alternative career pathways for these researchers outside academia, including:

- Many industries are increasingly driven by knowledge assets and the ability to innovate is critical for company survival
- Many companies are collaborating in their research and innovation efforts, with trends towards increasingly 'open science'
- New ways of diffusing knowledge and technologies into and through the innovation system are being developed

23 LERU, 2018. Delivering talent: Careers of researchers inside and outside academia (LERU Position Paper). League of European Research Universities (LERU), Leuven, Belgium

- Companies increasingly require the types of research and analytical skills that are developed through the doctoral process and postdoctoral research experiences
- Postdoctoral researchers are often a core resource within universities that underpins much of the research activity within university-industry partnering activity. They are thus gaining experience of working collaboratively across organisational boundaries; a key capability in an open-innovation world

Reflecting these changes, the study observed the following key trends:

- There are more researchers in the private sector than in academia
- Employment rate of doctoral graduates is higher than for any other level of education
- Early stage researchers increasingly move from academia into the private or public sector
- New career pathways and opportunities are opening up (entrepreneurship, boundary research, research/non-research jobs are becoming more permeable)

The LERU study found that while early career researchers had a high level of motivation about their jobs, they were uncertain about their career prospects. This was particularly the case for postdoctoral researchers. The study also found a reluctance of early stage researchers to make the transition to jobs in the private or public sector outside academia. Crucially, it finds that much of the career support provided by supervisors and principal investigators focuses on careers within academia, with much less support provided for those looking for career opportunities elsewhere. Overall they found that early career researchers were often insufficiently prepared for the non-academic labour market.

The LERU study suggests that the typical on-the-job training provided to researchers is no longer sufficient, with early stage researchers needing a wide variety of skills. Training needs to focus both on the needs of their current academic job as well as their future careers, with advice and support providing for both future academic jobs and transitions into the private and public sectors.

This led to calls by LERU for universities and governments to revisit how we develop doctoral students and postdoctoral researchers and recognise that most will not become academics. It argues that with appropriate training and nurturing, universities can provide an important feedstock of human capital to drive research and innovation in the private and public sectors, and increase entrepreneurial activity in the economy. The study sets out core elements of a vision to achieve this change and realise the ambitions, including[24]:

- Universities and research institutions commit at the highest level and throughout the organisation to develop policies and initiatives to improve the attractiveness of careers of researchers with a three-fold objective:
  - to train new generations of researchers prepared and ready to take up a large variety of jobs inside and outside the university,
  - to nurture and retain a pool of researchers within academia to ensure that frontier research breakthroughs, a hallmark feature of research-intensive universities, continue to find fertile ground in universities, and
  - to encourage productive knowledge exchange between all stakeholders in research capital.
- Universities and research institutions ensure that pursuit of diversity is deep-rooted in procedures for recruitment and promotion and in career development programmes.
- Employers outside academia engage in discussions with universities and research institutions on the development of skills training programmes that enable successful transfer of researchers and in discussions about removing barriers for mobility from and to universities.

24 The full vision and the associated recommendations can be found in the LERU study, p.3

- Supervisors and principal investigators do not solely focus on the perspectives within academia for their staff but adopt a broader view on pathways. They recognise and discuss possible discrepancies between expectations of doctoral and postdoctoral researchers about the probability of an academic career and the reality.
- Doctoral and postdoctoral researchers take the opportunities for professional development that universities and research institutions offer. This includes qualification in research and teaching, but also in transferable, professional and soft skills.
- Stakeholders work together to take away cultural ambivalence about taking up training that appears to take time 'away from the lab' and/or is focused on career pathways outside academia. Universities and research institutions commit to making reasonable time available (e.g. ten days per annum) for personal and career development activities that do not relate solely to current research capability.
- Governments facilitate flexible career pathways to ensure mobility connecting academia, the private and the public sector. In order to achieve permeability between the systems, universities are relatively flexible with respect to salary.

Increasing people mobility and the need for joint appointments

Discussions at the Summit also called for more mobility of people between universities and industry. This movement provides an important mechanism for bridging the gaps in cultures, motivations and objectives between academia and industry which can hamper the effectiveness of partnerships. Among other things, they can:

- Facilitate the building up of academia-industry networks
- Bring 'user' perspectives to inform the direction of the research agenda and individual projects
- Provide critical insights on how research outputs need to be developed in order to create applications that can be deployed in practice
- Help to identify opportunities for new partnerships and research commercialisation
- Help other companies and innovating organisations better understand the potential value of the research being undertaken within the university
- Provide an important conduit for the exchange and diffusion of knowledge between universities and companies

Delegates highlighted how this was much more common in some disciplines, such as medicine, engineering, law, and architecture, which have long had joint appointments and embedded industrial professors such as professors of practice. In other disciplines such positions are rare albeit with some suggestions they may be growing. One recent example highlighted at the Summit was the new artificial intelligence lab recently launched by Princeton University and Google to "deepen our understanding of machine learning and produce exciting innovations"[25]. The two professors who lead the lab will now split their time between working for the University and Google.

25 LERU, 2018. Delivering talent: Careers of researchers inside and outside academia (LERU Position Paper). League of European Research Universities (LERU), Leuven, Belgium

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Reconnecting with the public on the value of research

There are lots of wicked, challenging problems that need to be solved to improve peoples' lives and increase their life chances. Governments, universities, companies, and others working together towards addressing common goals is key to finding solutions to these types of challenges. Indeed, universities in the US, UK, across Europe, and elsewhere, are more engaged in this type of impact-driven work than ever before.

At the same time, surveys of public opinion show that universities are devaluing in the public mind. This is particular concerning given that advancing knowledge to contribute to society and improving the human condition is often at the heart of most research universities' missions, and that research funders have, in recent years, been increasingly including considerations of impact in the distribution of funding.

Concern was expressed at the Summit that, as a community, we were not doing enough to demonstrate how universities, and the partnerships they form with industry and others, help to improve the human condition and contribute to the betterment of society. One significant challenge is that impacts from research – particularly from more basic, fundamental research – may take many years, if not decades, to materialise. For much of this time, the accumulating knowledge may well remain within the academic base before finding its way into the wider economy and society.

Another challenge is that, while there are an increasing number of initiatives underway to develop and deliver societally responsive and impact-driven research, they are often distinct and siloed. In the US, the experience is that they also tend to use their own vernacular, for example around grand challenges, community-based participatory research, convergence research, and highly integrative basic and responsive research.

To address this issue in the US, the Summit heard from the experience of the Association of Public and Land-grant Universities (APLU) in creating the Public Impact-Focused Research (PIR) initiative. This aims to create an overarching concept for the many and varied societally responsive research initiatives and help to drive a strategic, transformative movement that:

- Develops a common vernacular and framework to describe efforts and allow universities and their partners to showcase key initiatives and impacts on society
- Encourages universities to expand public impact-focused research portfolios
- Identifies and communicates best practices
- Identifies and mitigates barriers for universities and partners for this type of activity

These goals need to be achieved in the context of strengthening and integrating the support for fundamental research. Crucially, the 'public impact-focused research' concept seeks to convey that an increasing amount of basic and applied research is in collaboration with, and in service to, the public. It recognises that the distinction between 'basic' and 'applied' research is a thing of the past; rather it is often a question of when research will have an impact on society.

The ambition of PIR is to provide framework to help universities and their partners create incentives, align strategic visions, and invest more effectively to deliver more societally-focused and impactful research.

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Moving Forward

Much progress has been made over the past decade in improving the value and effectiveness of university-industry partnerships. These partnerships between academia, companies, governments and others play an increasingly important role in delivering the solutions to the many and varied challenges we face in our societies and industries to improve the human condition.

However, with rapidly changing socio-economic, political technical and industrial landscapes, our university-industry partnering community cannot afford to stand still. We must continually learn from our experiences, reflect on what works and what does not. We must adapt as necessary to ensure we can deliver increasing value to our target communities in the economy and society. We must be willing to adapt our existing models as well as experiment with new ways of working.

We must find ways of broadening our partnerships beyond the traditional focus on science and technology to more effectively integrate the social sciences and humanities, and beyond the traditional focus on large R&D intensive companies to extend further into supply chains and into sectors that have not yet benefitted from active partnerships with the university base. As a community of universities, companies and government agencies, we must come together to find ways of overcoming the variety of barriers that hamper our ability to work together; barriers that are long-standing as well as the challenges emerging as universities expand their engagements beyond their traditional partners and sectors.

The report also highlights the growing recognition of the value of diversity – in all its forms – in university-industry partnerships. We must continue to encourage the formation of more diverse teams at the heart of these partnerships recognising the distinct value of bringing together individuals different perspectives and life experiences to contribute to the innovation effort. We are on the cusp of real and lasting acceptance of the value of diversity in the workplace. We must not lose momentum, and find ways of cementing the progress made to-date.

The rise of big data and the capabilities of artificial intelligence and data science tools are transforming what is possible in many industries and how decisions are made. Given the potential of these technologies it is unsurprising that they are becoming an increasing focus for many university-industry partnerships. However, the rise of these approaches bring with it significant ethical concerns – not least around privacy, accountability, individual empowerment, and bias – that need to be addressed. Furthermore, partnerships built around these technologies are presenting new types of barriers that need to be overcome, for example around secure data access, storage and sharing, responsiveness, and valuing outputs. As a community, we must be at the forefront of ensuring the ethical deployment of AI and big data approaches.

Metrics that capture the capabilities and performance of universities and their partnerships with industry continues to be an important issue for universities, companies and governments. The availability of robust and comparable data for partnering remains patchy compared for example to that available for spinouts and technology licensing. Different organisations in different countries are exploring how to develop more robust data to inform partnering decisions and evaluate performance. However, they remain relatively unconnected. It would appear timely to bring together the various exercises across different organisations and

countries to share experiences and insights, and find ways of developing more standardised and internationally comparable metrics for building effective university-industry partnerships.

Effective partnerships between universities, companies, governments and others are crucial for finding solutions to the many and varied critical and complex challenges facing societies, not least those associated with climate change and sustainability and an increasingly ageing population. Despite the increasingly critical contributions of these partnerships, surveys of public opinion show that universities are devaluing in the public mind. As a community we must find ways of engaging with the public at large and demonstrate to them the value of universities and the partnerships they form with industry.

12.1 Further resources

Oxford UIDP Summit website https://uidp.org/event/oxford_uidp_summit/
Presentation slides online https://uidp.org/custom-type/oxford-uidp-summit/
Presentation video online http://podcasts.ox.ac.uk/series/oxford-uidp-summit

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